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Soil Site Index for Georgia Slash Pine

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INTRODUCTION

Estimating land value from soil properties is not new; farmers have been buying land on a basis of taste, feel, and color for many years. As forest land cost has increased, however, the need for better methods of estimating its productive capacity has also increased. As a result, much progress has been made in the past 20 years in classifying forest land productive potential on the basis of measurable soil properties. Utilizing this method, the study reported in this paper provides an estimate of the productive capacity of old-field sites in the middle coastal plain of Georgia for slash pine plantations.

FIELD PROCEDURE

Observations of stand and site conditions were taken in 214 slash pine plantations in the middle coastal plain of Georgia. All of the counties in this region were searched for suitable plantations, and study areas were found in all but four (fig. 1). These plantations ranged in age from 8 to 27 years and in site index from 35 to 85 feet at 25 years[2] (table 1). The plantations included in the sample showed no evidence of growth loss from burning, insects, or disease.

Two soil pits were dug on each plot (fig. 2). Profile measurements were taken from these holes, as well as from supplementary auger borings, so that the average soil conditions found on the site could be described. On each plot, the average height and age were obtained for six dominant or codominant trees growing near the soil observation points.

1/ This publication represents the combined research efforts of the School of Forestry, Duke University, and the Southeastern Forest Experiment Station. Special acknowledgement is due Dr. C. W. Ralston, Duke University, for guidance and advice in this study.

2/ Preliminary site index estimates were made from curves prepared by Robert L. Barnes for Florida slash pine in "Growth and yields of slash pine plantations in Florida." Fla. Univ. School Forestry Res. Rpt. 3, 23 pp.

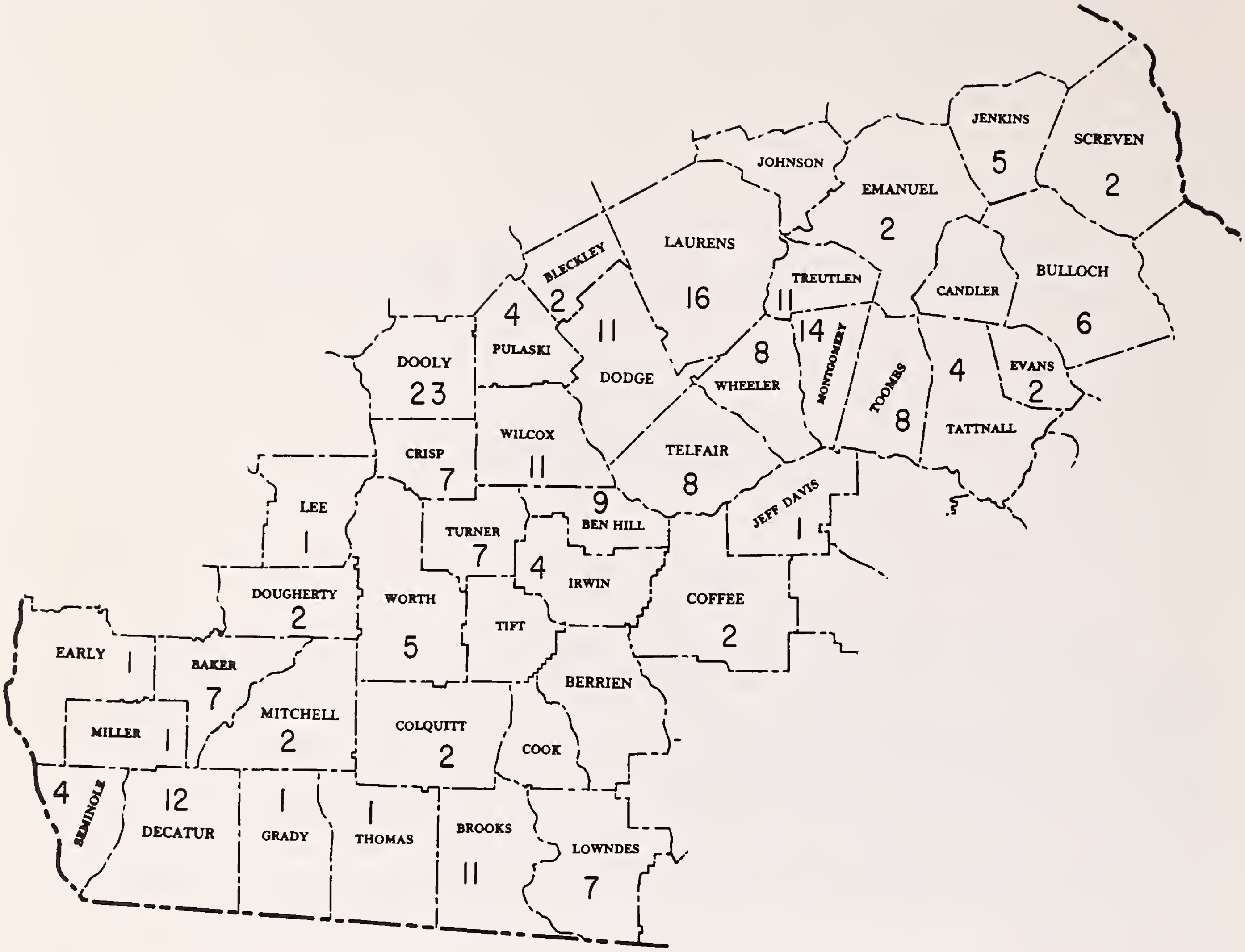

Figure 1.--A map of the Georgia middle coastal plain indicating sample plot locations.

Table 1.--Plot distributions based on age and site index

Age class (years)	Site index class (total height at 25 years)				
	40	50	60	70	80
	Number of plots				
10	0	5	10	34	1
15	4	2	40	61	6
20	0	2	11	30	1
25	2	1	2	2	0
Total	6	10	63	127	8

Figure 2.--Soil profile holes were dug on each plot to measure the thickness of the A_1 horizon and the depth to a fine-textured horizon. Supplementary auger borings were made to check uniformity of the soil characteristics throughout the plot.

STATISTICAL PROCEDURE

The relationship of soil properties to tree height was tested by regression methods. The following equation provided the best estimate of tree heights:

$$\text{Logarithm of dominant tree height (in feet)} = 2.0058 - 5.5907\left(\frac{1}{\text{Age}}\right) + 0.005968\,(\text{thickness of the } A_1 \text{ horizon, in inches}) - 0.1445\left(\frac{1}{\text{thickness of } A_1 \text{ horizon, in inches}}\right) + 0.001837\,(\text{depth to fine texture, in inches}) - 0.000032\,(\text{depth to fine texture, in inches})^2$$

Eighty-seven percent of the variation is explained by this equation, with the soil variables alone accounting for 18 percent of this variation. The error of estimate of a single observation is approximately 10 percent.

The use of the predicting equation as such is too time consuming for normal field use. In order to simplify applications, a table has been prepared that indicates site index at age 25 as estimated from the two significant soil properties (table 2). If tree height estimates are desired at ages other than 25 years, the alignment chart (fig. 3) provides a rapid graphic solution of the regression equation. Note that the age of plantations sampled extended only through 27 years and the data are extrapolated to 50 years. The extrapolated portion of the data should be used with caution.

Table 2.--Soil site index (total height at age 25)

Thickness of A_1 horizon (in inches)	Depth to a fine-textured soil layer (in inches)								
	10	20	30	40	50	60	80	100	110
	- -				Feet	- -			
1	46	47	47	46	45	43	38	33	30
3	57	60	60	59	57	56	50	42	37
6	65	66	67	66	64	62	55	47	42
9	67	70	71	70	67	66	57	49	44
12	--	74	74	73	72	69	61	52	47

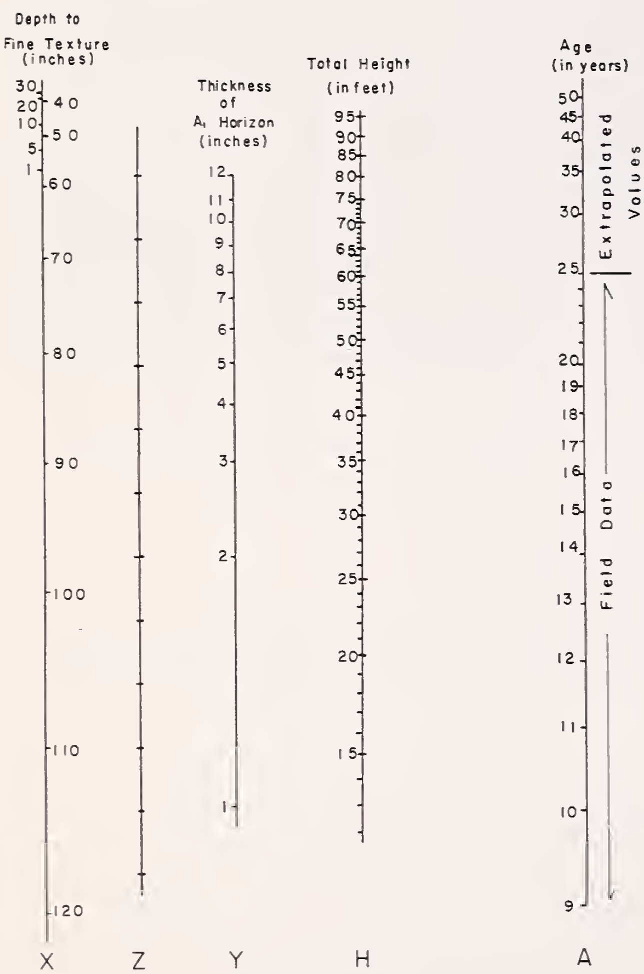

Figure 3.--An alignment chart for estimating height of slash pine. To make a height estimate for an old field:

1. Measure thickness of the A_1 horizon and the depth to a fine-textured horizon.
2. Plot the thickness of the A_1 horizon on line Y, and plot the depth to a fine-textured horizon on line X.
3. Join the points on line X and Y with a straight line and mark the point where the line intersects line Z.
4. Join a line from the point on line Z to the described age point on line A.
5. Read the height estimate from the point of intersection on line H.

APPLICATION OF RESULTS

Several operations are necessary to establish the slash pine growth potential for an area. First, soil sampling procedures must be determined. Sampling points can be established with either a soil auger or post hole digger, depending on the depth and wetness of the soil. As the hole is dug, a record should be made of the thickness of the A_1 horizon and the depth at which a fine-textured soil is reached (fig. 4). A 25-year site-index estimate for the point can be obtained by reading the value in table 2. If the site values for all the points are plotted, a contour map of site indices in the same range can be made.

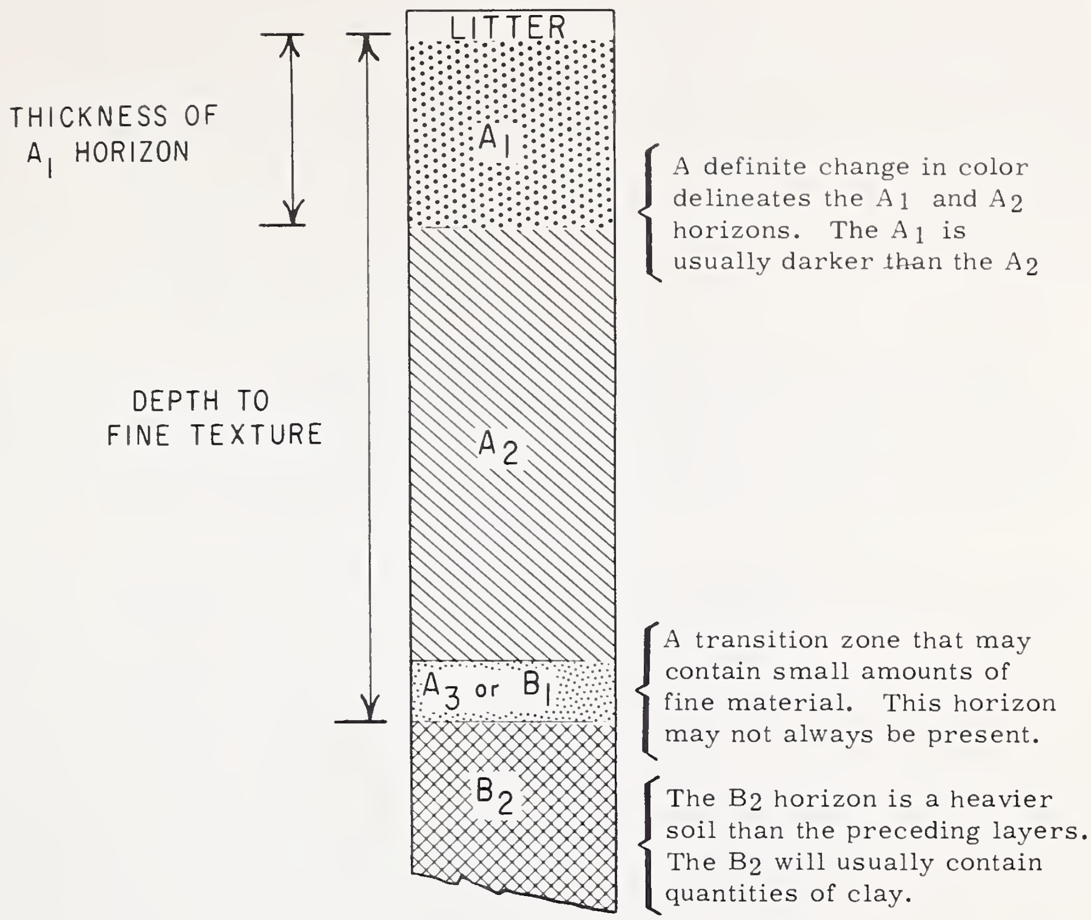

Figure 4.--A typical soil profile in the middle coastal plain of Georgia.

The A_1 horizon is easy to recognize. It is generally the 3- to 8-inch-thick surface layer of soil. This layer is almost always several shades darker because it contains incorporated or infiltrated organic matter and is sharply delineated from the next layer, or A_2 horizon.

The recognition of a fine-textured horizon can be more difficult. Generally, this horizon will be a subsoil containing a quantity of clay. On the sandy soils, however, this horizon might be a sandy loam or a silt loam. In other words, whenever a clear change to a finer texture is noted, the depth to this point is taken as one of the estimating variables.

The intensity of soil sampling depends upon the local soil variability and the number of site classifications desired. It is suggested that site indices be obtained so that the contour map of site indices classifies sites differing by not less than 10 site index units; i.e., separates site index 40 from 50, 50 from 60, etc.

It is also suggested that soil samples be spaced at the rate of one per acre as a preliminary step. If adjacent samples show a difference in calculated site index of less than 10 units, the sampling intensity can be decreased to one sample per five or ten acres. In cases where extreme changes occur in physiography--or in the soil characteristics themselves--it may be necessary to sample at an intensity of greater than one sample per acre.

A rough estimate of site index can be obtained from table 3 if soil maps are available that supply the necessary soil series information. It should be noted that 142 plots were taken in three soil series (Lakeland, Norfolk, and Tifton) and the variation between plots of the same series is as much as 20 feet at 25 years.

Table 3.--Average site index (at age 25 years) for the soil series examined in the middle coastal plain of Georgia

Soil group	Soil series	Plots	Average site index[1] (at age 25 years)	Range in site index
		Number	Feet	Feet
Azonal deep sands	Kershaw			
	Old field planting			
	Normal	3	56	43 to 66
	Topsoil removed	2	37	35 to 39
	Forest planting (turkey oak)	7	44	32 to 48
Zonal red-yellow podzolic soils	Lakeland	36	68	58 to 76
	Norfolk	56	69	61 to 81
	Tifton			
	Normal	50	67	60 to 74
	Eroded	2	58	55 to 60
	Ruston	12	68	63 to 74
	Gilead	15	67	61 to 75
	Cuthbert			
	Normal	3	64	60 to 66
	Eroded	3	53	52 to 53
	Orangeburg			
	Eroded	3	56	51 to 59
	Americus	2	66	65 to 68
Interzonal planasol	Susquehanna	2	68	67 to 68
Low humic glei	Blanton	4	73	70 to 75
	Coxville	2	66	64 to 68
	Lynchburg			
	Old field planting	3	69	67 to 72
	Forest planting (gallberry and palmetto)	2	64	62 to 65

1/ Standard deviations for Kershaw old fields ± 7.1, Lakeland ± 4.6, Norfolk ± 5.0, Tifton normal ± 3.3, Ruston ± 3.3, Gilead ± 3.8, and Blanton ± 2.1. The numbers of observations on the other soils were too small to warrant calculation of the standard deviations.

DISCUSSION

The results of this study show that tree heights can be correlated with two specific properties of soil--thickness of A_1 horizon and depth to a fine-textured horizon--which affect soil water, aeration, and nutrient levels. Therefore, interpretation of the present study results should consider how variations in these two properties of the soil affect the moisture and nutrient supply and aeration of the tree.

A look at the alignment chart (fig. 3) shows that an increasing thickness of the A_1 horizon is related to an increase in site quality. The thicker A_1 horizon contains a higher total supply of organic matter and mineral elements. The higher total supply of organic matter also improves the water-holding capacity--an important consideration in sandy soils.

The relationship of the depth to a fine-textured horizon to tree height growth is somewhat more involved. Optimum growth was found on sites having a depth to a fine-textured horizon of 28 to 30 inches. On sites where depth to a fine-textured horizon is greater than 30 inches, moisture becomes limiting because of the poor waterholding capacity of the surface horizons. There also seems to be a tendency for surface soils to become coarser as the depth to fine texture increases. On the shallow sites, where the fine texture is closer to the surface than 28 inches, a number of conditions can develop which adversely affect tree growth. Percolation rates on such sites are apt to be slow, with poor internal drainage and excessive runoff. If the internal drainage is poor, aeration can become a limiting factor to tree growth. If the runoff is excessive, erosion will remove a portion of the A_1 horizon.

Although an effort was made to collect data from poor sites (fig. 5), a large proportion of the sampled areas supported slash pine plantations with site indices of 60 feet or better at 25 years (table 1). The poorer sites were found on eroded phases of the zonal red-yellow podzolic soils or on azonal deep sands. Relatively few plots were taken on these sites because of the limited occurrence of these soil conditions in the middle coastal plain of Georgia.

The plantations sampled were usually on old fields; the few woods plantings that were included were found on deep sands. Therefore, it is important to note that the data in this study applies primarily to old-fields with normal soil profiles.

This study indicates that the work of Barnes and Ralston[3/] was applicable to many of the Georgia middle coastal plain soils. In studying soil factors relating to growth of slash pine plantations in Florida, they showed the following factors to be significant in predicting height growth: reciprocal of age, depth to mottling, depth to a fine-textured horizon, and the silt-plus-clay content of the heaviest horizon. They did not, however, utilize the thickness of the A_1 horizon as a height predicting factor.

3/ Barnes, R. L., and Ralston, C. W. Soil factors related to growth and yield of slash pine plantations. Fla. Agr. Expt. Sta. Tech. Bul. 559, 23 pp. 1955.

Figure 5.--The plantation on the top is a 13-year-old stand on a deep sand (site class 45). Note that only a few of the larger trees have reached merchantable size for pulpwood. The plantation on the bottom is growing on a site which has a fine-textured subsoil (site index 70) at a depth of three feet and, although only a year older than the plantation on the top, has demonstrated a much greater capacity for growth.

Kreis, Bennett, and Patterson[4] also tested Barnes' and Ralston's formulation in slash pine plantations in the middle coastal plain of Georgia. Their work indicated that the basic equation of Barnes and Ralston agreed closely with the observed site quality on the deeper soils, and the deviation in height was only 1.4 feet. On shallow soils, however, with a depth of mottling of less than 10 inches, the average deviation was approximately 22 feet.

The present study incorporated plots with shallow and eroded soils, was comprehensive in area coverage, and was restricted to the middle coastal plain of Georgia. In addition, it meets the objections of extrapolating Barnes' and Ralston's work into the study area.

SUMMARY

The purpose of this study was to establish a relationship between soil properties and site index for slash pine plantations in the middle coastal plain of Georgia. In the course of this study, 214 sample plots were established throughout the study area.

The soil properties found to be highly correlated with height growth were the thickness of the A_1 horizon and the depth to a fine-textured horizon. Site quality increases as the thickness of the A_1 horizon increases. Optimum growth was found on sites having a depth to a fine-textured horizon of 28 to 30 inches. On sites where this horizon was shallower or deeper, an adverse effect on height growth was indicated.

For field use of the data, a table and an alignment chart have been prepared to supply a direct height estimate based on the two soil variables. Average site values for the various soil series samples have been calculated and presented in tabular form.

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[4] Kreis, E. A., Bennett, F. A., and Patterson, A. E. A site prediction test in slash pine plantations in the middle coastal plain of Georgia. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Notes 93, 2 pp. 1956.

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